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NLPGA

National LP-Gas Association · 1301 West 22nd Street · Oak Brook, Illinois 60521 · 312-573-4800

February 25, 1988
File: Tbpt-631

Mr. Alan I. Roberts, Director
Office of Hazardous Materials Regulations
Research & Special Projects Administration
U.S. Department of Transportation
400 Seventh St. SW
Washington, DC 20590

Subject: Seasonal Filling Densities for LP-Gas Cargo Tanks

Dear Mr. Roberts:

NLPGA recommends amendment of Section 173.315(b) of the Hazardous Materials Regulations to provide increased filling limits of liquefied petroleum gas (LP-gas) cargo tanks. Limiting conditions and a revision to Table 173.315(b) are enclosed.

The National LP-Gas Association (NLPGA) is the national trade association of the LP-gas industry with a membership over 4,100, including 47 affiliated state and regional association representing all 50 states. A very significant part of our membership are local LP-gas retail marketers, though our membership also includes common and contract motor carriers of LP-gas. Thus, our members have a very direct and concerned interest for regulations that affect the design and operation of MC-330 and MC-331 cargo tanks.

In support of this proposed amendment, we are enclosing a report of research performed on tank filling densities by the School of Chemical Engineering, Oklahoma State University, Stillwater, Oklahoma. This research was initiated by the National LP-Gas Association with the University in 1969 and after an unavoidable delay was completed in 1978. This data was originally submitted to DOT by NLPGA in a petition for rule making dated October 23, 1978. The petition was subsequently returned by DOT on May 20, 1986 with the request that the proposal be reviewed to determine if it was still valid considering recent changes in technology and regulations.

This letter resubmits a proposed change to the Hazardous Materials Regulations along with this OSU research report. As applied to Commercial and Special Duty Propane (see ASTM D-1835, copy enclosed), the data in this research report indicates the following change can be made with no sacrifice in safety. These changes are reflected in the following proposed addition to the table in Section 173.315(b).

<u>Winter (November through March) filling of cargo tanks:</u>

A filling density of 47.5% of water weight capacity for two ranges of specific gravity "0.496 to 0.503" and "0.504 to 0.510" for over the road cargo tanks, provided (1) these containers are normally emptied within three days of filling and (2) these containers are filled at liquid temperatures below 70 F.

These changes would contribute materially toward the conservation of energy resources by reducing the number of trips necessary to transport this fuel to the consumer. From a safety standpoint, a reduction in the number of trips would also reduce the overall exposure of tank trucks to the highway environment. The Winter is a peak period for transportation of propane. By permitting trucks to carry more product per trip under the qualifications set out, consumer outages attributed to transportation problems during extreme weather conditions would be minimized. In summary, we feel that adoption of the proposed changes would be beneficial to the consumer, the industry and the government.

LP-gas cargo tanks are of two basic types - bobtails and highway transports. Bobtails are local delivery units; the common capacity of a bobtail is 2,000 to 3,500 gallons water capacity (gwc) with 2,500 gwc being a typical size.

Highway transports are articulated units, commonly called semi-trailers, and are pulled by highway tractors. These vehicles usually have a capacity of 7,500-11,000 gwc, may range several hundred miles or more, and are used primarily for distance bulk transportation of LP-gas between pipeline terminals and local distribution facilities. There is a third type (used mostly on the West Coast) that uses a large, tandem-axle bobtail unit in combination with a second cargo tank mounted as a full trailer. These combination units transport LP-gas in the same general quantities as a highway transport unit, and would have the same economic benefits as a transport with respect to seasonal filling densities.

There are an estimated 6,000 highway transports in the United States transporting. The annual savings in delivery costs would be about $17,400,000. There are an estimated 18,000 bobtails in the United States in LP-gas service. The approximate annual savings for these vehicles is $19,350,000. The derivation of these respective savings is enclosed.

In addition to the economic benefit that would be realized with these winter filling densities, there would be a contribution towards improved safety in transportation. Any time that it becomes possible to decrease the number of vehicle movements over the highways, there is a demonstrated improvement in safety. This improvement occurs because the number of possibilities for an incident to occur have been reduced. Thus, the economic benefit provided by the higher winter filling densities would be supplemented by improved safety experience in LP-gas transportation.

We have heard various concerns expressed for the possible effect of seasonal filling densities upon LP-gas tank trucks in areas such as Puerto Rico, where there are virtually no seasonal temperature changes. Enclosed is a copy of temperature data for San Juan, Puerto Rico covering the period 1898-1947; this data was obtained from the National Oceanic and Atmospheric Administration, National Meteorological Center. The center column shows maximum and minimum temperatures recorded in the particular month. For the 48-year period, the maximum daily temperature in the months November-March was 93 F, well below the 120 F maximum daily temperature recorded for Yuma, Arizona for a 69-year period. Similar data for Yuma provided by NOAA also is enclosed. Thus, there would be no adverse effect upon LP-gas shipments in Puerto Rico using the proposed winter filling densities. Yuma, Arizona is one of the data points included in the research conducted by Oklahoma State University referenced earlier in this letter.

We would be glad to discuss the research data and this petition for rule making at your convenience. Representatives of Oklahoma State University also are available to discuss the more technical aspects of the research work and report.

Sincerely,

W H Butterbaugh

W. H. Butterbaugh, CAE
Assistant Vice President
Technical Services

WHB/cl

Enclosures See Docket File/Sdc

ASTM D 1835 - 76

Standard Specification for
LIQUEFIED PETROLEUM (LP) GASES[1]

, Standard is issued under the fixed designation D 1835; the number immediately following the designation indicates year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the r of last reapproval.

Scope

1.1 T /specification covers those prod- s commonly referred to as liquefied petro- n gases.

.2 This specification is applicable to prod- ; intended for use as domestic, commer- . industrial, and engine fuels.

3 This specification is for use in formulat- specifications for required properties of efied petroleum gases at the time of deliv- in bulk.

pplicable Documents

1 *ASTM Standards:*

1265 Sampling Liquefied Petroleum (LP) Gases[2]

267 Test for Vapor Pressure of Lique- ied Petroleum (LP) Gases (LP-Gas Method)[2]

657 Test for Specific Gravity of Light lydr)bons by Pressure Hydrometer[2]

837 Test for Volatility of Liquefied Pe- oleum (LP) Gases[3]

338 Test for Copper Strip Corrosion by iquefied Petroleum (LP) Gases[3]

58 Test for Residues in Liquefied Pe- leum (LP) Gases[3]

63 Analysis of Liquefied Petroleum P) Gases and Propylene Concentrates Gas Chromatography[3]

20 Test for Hydrogen Sulfide in Lique- d Petroleum (LP) Gases (Lead Ace- e Method)[3]

8 Calculation of Certain Physical perties of Liquefied Petroleum (LP) es from Compositional Analysis[3]

3 Test for Dryness of Propane (Valve eze Method)[3]

4 Test for Sulfur in Liquefied Petroleum Gases (Oxy-Hydrogen Burner Lamp)[3]

2.2 *Other Documents:*

GPA Publication 2140[4]

3. Types

3.1 Four basic types of liquefied petroleum gases are provided to cover the common use applications, as follows:

3.1.1 *Commercial Propane*—A hydrocarbon product for use where high volatility is required.

3.1.2 *Commerical Butane*—A hydrocarbon product for use where low volatility is required.

3.1.3 *Commercial PB Mixtures*—Mixtures of propane and butane for use where intermediate volatility is required.

3.1.4 *Special-Duty Propane*—A high-quality product composed chiefly of propane, which exhibits superior antiknock characteristics when used as an internal combustion engine fuel.

4. Detail Requirements

4.1 The four types of liquefied petroleum gases shall conform to the requirements prescribed in Table 1.

5. Sampling

5.1 Proper sampling of liquefied petroleum gases is extremely important if the tests are to be significant. All samples shall be obtained in accordance with Method D 1265.

[1] This specification is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants.
Current edition approved Aug. 27, 1976. Published October 1976. Originally published as D 1835 - 61 T. Last previous edition D 1835 - 75.

[2] *Annual Book of ASTM Standards*, Part 23.

[3] *Annual Book of ASTM Standards*, Part 24.

[4] Available from Gas Processors Assn., 1812 First Place, Tulsa, Okla. 74103.

ppm x 0,814 = grains/100 ft^3

TABLE 1 Detail Requirements for Liquefied Petroleum Gases

	Product Designation				
	Commercial Propane	Commercial Butane	Commercial PB Mixtures	Special-Duty Propane[A]	ASTM Test Methods (see Section 2)
Vapor pressure at 100°F (37.8°C), max, psig	208	70	[B]	208	D 1267 or
kPa	1430	485		1430	D 2598
Volatile residue:					
evaporated temperature, 95 %, max, °F	−37	36	36	−37	
°C	−38.3	2.2	2.2	−38.3	D 1837
or					
butane and heavier, max, vol %	2.5	. . .	. . .	2.5	D 2163
pentane and heavier, max, vol %	. . .	2.0	2.0	. . .	D 2163
Propylene content, max, vol %	. . .	. . .	. . .	5.0	D 2163
Residual matter:					
residue on evaporation 100 ml, max, ml	0.05	0.05	0.05	0.05	D 2158
oil stain observation	pass[C]	pass[C]	pass[C]	pass[C]	D 2158
Relative density (specific gravity) at 60/60°F (15.6/15.6°C)	[D]	[D]	[D]	. . .	D 1657 or D 2598
Corrosion, copper, strip, max	No. 1	No. 1	No. 1	No. 1	D 1838
Sulfur, grains/100 ft³ max at 60°F and 14.92	15	15	15	10	
psia mg/m³ (15.6°C and 101 kPa)	343	343	343	229	D 2784
Hydrogen sulfide content	. . .	. . .	. . .	pass[E]	D 2420
Moisture content	pass	. . .	. . .	pass	D 2713
Free water content	. . .	none[F]	none[F]	. . .	

[A] Equivalent to Propane HD-5 of GPA Publication 2140.

[B] The permissible vapor pressures of products classified as PB mixtures must not exceed 200 psig (1380 kPa) and additionally must not exceed that calculated from the following relationship between the observed vapor pressure and the observed specific gravity:

$$\text{Vapor pressure, max} = 1167 - 1880\ (\text{sp gr } 60/60°F) \text{ or } 1167 - 1880\ (\text{density at } 15°C)$$

A specific mixture shall be designated by the vapor pressure at 100°F in pounds per square inch gage. To comply with the designation, the vapor pressure of the mixture shall be within +0 to −10 psi of the vapor pressure specified.

[C] An acceptable product shall not yield a persistent oil ring when 0.3 ml of solvent residue mixture is added to a filter paper, in 0.1-ml increments and examined in daylight after 2 min as described in Method D 2158.

[D] Although not a specific requirement, the specific gravity must be determined for other purposes and should be reported. Additionally, the specific gravity of PB mixture is needed to establish the permissible maximum vapor pressure (see Footnote *b*).

[E] An acceptable product shall not show a distinct coloration.

[F] The presence or absence of water shall be determined by visual inspection of the samples on which the gravity is determined.

APPENDIX

X1. SIGNIFICANCE OF ASTM SPECIFICATIONS FOR LIQUEFIED PETROLEUM (LP) GASES

X1.1 General

X1.1.1 Liquefied petroleum gas products are composed of those readily liquefiable hydrocarbon compounds which are produced in the course of processing natural gas and also in the course of the conventional refining of crude oil. The composition of liquefied gases can vary widely depending upon the source and the nature of the treatment to which the products have been subjected.

X1.1.2 There are many uses for liquefied petroleum gases. Important uses are, (*1*) as domestic, commercial, and industrial fuels, (*2*) as a carbon source material in metal treating operations, (*3*) as refinery raw materials for synthetic gasoline production, and (*4*) as petrochemical raw materials. The nature of the needs dictates the required composition characteristics in these various applications. Since the last three uses of those listed are in the category of specialty applications which involve special requirements, they are excluded from consideration in the specifications.

X1.1.3 In substance, the ASTM Specifications for Liquefied Petroleum Gases are designed to properly define acceptable products for domestic, commercial, and industrial uses. In many cases it will be found that products meeting the specifications will also be usable in applications other than the ones for which they were designed. The following may be accepted as a general guide in the more on use applications of the three types of

1.3.1 *Commercial Propane*—This fuel type one preferred for domestic, commercial, and rial use, particularly in geographical areas ı seasons where low ambient temperatures ›mmon, and where uniformity of fuel is an tant consideration.

.1.3.2 *Commercial PB Mixtures*—This fuel since it covers a broad range of mixtures, ts the tailoring of fuels to specific needs. The ıs mixtures find application as domestic, comal, and industrial fuel in areas and at times low ambient temperature conditions are less ›ntly encountered.

.1.3.3 *Commercial Butane*—This fuel type limit plication as a domestic fuel in areas rmer c..nates. It is similarly used in industrial :ations where problems of fuel vaporization ›t present.

.1.3.4 *Special-Duty Propane*—This fuel type ›ecial liquefied petroleum gas product tailored et the restrictive needs of internal combustion es operating under moderate to high engine ity. Fuel products of this type will be less ble in composition and combustion character- than the other products covered by this speci- on.

Significance

1.2.1 Since commercial liquefied petroleum ; are essentially either single component prod- depending upon fuel type, it follows that all of nportant behavior characteristics of such prod- can be defined and controlled by a relatively simple measurements. The specification tests h are provided achieve the desired result. The ficance of the various tests as they may apply nsumer problems is summarized here.

1.2.1.1 *Vapor Pressure, Volatility, and Grav-*

1.2.1 *Vapor Pressure* is an indirect meas- ›f the most extreme low-temperature condi- under which initial vaporization can be ex- ›d to take place. It can be considered as a quantitative measure of the amount of the volatile material present in the product. It also be used as a means for predicting the mum pressures which may be experienced at tank temperatures. Vapor pressure becomes significant when it is related to volatility.

1.2.1.1.2 *Volatility*, expressed in terms of the evaporated temperature of the product, is a sure of the amount of least volatile fuel compo- present in the product. Coupled with a vapor sure limit, it serves to assure essentially single- ponent products in the cases of commercial ane and commercial butane fuel types. When tility is coupled with a vapor pressure limit h has been related to gravity, as in the case of commercial PB-mixture type of fuels, the com- tion serves to assure essentially two component ures for such fuels. When coupled with a er vapor pressure limit, this measurement serves to assure that special-duty propane products will be composed chiefly of propane and propylene and that propane will be the major constituent.

X1.2.1.1.3 *Gravity*, by itself, has little significance. It becomes of value only when related to vapor pressure and volatility. Since gravity is of importance in meeting transportation and storage requirements it is always determined for all liquefied petroleum gas products.

X1.2.1.2 *Other Product Characteristics*—While the vaporization and combustion characteristics of commercial liquefied gas products are completely defined for the normal use applications by vapor pressure, volatility, and gravity, as given in X1.2.1.1, there are other items which either affect or might affect the results obtained in some specific use applications. For that reason, limits are specified for residue content, copper corrosion, sulfur content, moisture content, and free water content to provide assurance of product dependability under the more extreme conditions of use.

X1.2.1.2.1 *Residue (End Point Index)* is a measure of the concentration of combustible hydrocarbon materials present in the product which are substantially less volatile than the liquefied petroleum gas hydrocarbons. Control over residue content is of considerable importance in use applications where the fuel is used in liquid feed systems. In such cases, failure to limit the permissible concentration of residue materials may result in troublesome deposits. It is also of importance where the fuel vapors are withdrawn from the top of the storage container. In such applications, regulating equipment tends to become fouled up if excessive amounts of residue are present in the field.

X1.2.1.2.2 *Copper Corrosion* limits are for the purpose of providing assurance that difficulties will not be experienced in the deterioration of the copper and copper-alloy fittings and connections which are commonly used in many types of utilization, storage, and transportation equipment. The further provision that special-duty propane products shall not contain detectable amounts of hydrogen sulfide is an added safeguard included for the same purpose.

X1.2.1.2.3 *Sulfur Content* limits are provided primarily for the purpose of more completely defining liquefied petroleum gas products since these products are inherently much lower in sulfur content than other petroleum-derived fuels. In the normal fuel use applications for liquefied petroleum gas, sulfur content is considered to be of limited significance if the other product characteristics are within the specified limits.

X1.2.1.2.4 *Moisture Content* is a measure of the approximate percentage saturation of the product with water. This measurement is a requirement only on the commercial and special duty propane types of liquefied petroleum gas. The purpose of moisture content control is to provide assurance that pressure reducing regulators and similar equipment will operate consistently without troublesome freeze-ups caused by the distillation of dissolved water from the product.

X1.2.1.2.5 *Free Water Content* is of importance only on the commercial PB-mixtures and commercial butane type products. These two types of products are normally used under ambient conditions which are mild and, as a consequence, the only requirement is vigilance to assure that no free water is present.

Highway Transports

Increased filling densities would provide immediate cost benefits to the transports that were built to comply with the previous Federal maximum weight limit of 73,280 lbs.; these units are typically 10,520 gallons water capacity (gwc). The present Federal weight limit of 80,000 lbs. would allow a LP-gas transport to be about 11,500 gwc fully loaded. Units designed to the 73,280 lb. limit could add 3,073 lbs. of propane from the increased filling density and still be well under the 80,000 lb. limit. Units designed to the 80,000 lb. limit would not benefit from additional cargo capacity since they are already operating at the maximum permitted weight. In addition, there would be some long range savings in the purchase of new tractors for older trailers which would not require the additional expenditure of weight savings specifications in order to haul maximum gallons.

Based upon a review of various issues of NLPGA LP-Gas Market Facts and other sources, there are approximately 7,000 transports in the United States. An estimated 1,000 of these units were designed and built to take advantage of the 80,000 lb. limit, leaving an estimated 6,000 units that could benefit from additional transportation capacity.

Typical Transport	10,520 gwc
Average number of trips (November through March)	200
Average hauling cost per gallon	$0.02

Difference in operating cost for additional transportation capacity is negligible.

Product Weight

Proposed winter filling density	(10,520 gal)(8.345 lb/gal)(4.85%) =	42,578 lbs.
Current winter filling density	(10,520 gal)(8.345 lb/gal)(45%) =	39,505 lbs.
Increased product load		3,073 lbs.

Increased gallons hauled (3,073 lbs)÷(4.24 lbs/gal) = 725 gallons propane

Annual savings per unit (725 gal/trip)(200 trips/winter)($0.02/gal) = $2,092/unit

Annual national savings ($2,900/unit)(6,000 units) = $17,400,000

Bobtails

It is generally recognized in the industry that the average cost of delivery for a bobtail is about $0.10 per gallon. As noted below, about 172 gallons additional LP-gas capacity would be realized with the proposed seasonal filling densities. This would permit one additional delivery per trip in most instances. If the increased capacity could be utilized only half of the time, estimated savings during the winter months would be $0.05 per gallon. This estimated utilization is actually quite conservative since most marketers deliver two truck loads a day during this November-March period.

In the long run, the increased filling densities would also tend to reduce the average size of vehicles required, thus keeping them more maneuverable and contribute towards reduced operating expenses.

The following calculation is based on the estimated savings of $0.05 per gallon, 25 days per month of deliveries, and one trip per day over the five winter months (November-March). A recent NLPGA survey concluded that there were about 18,000 bobtails in operation in the United States.

Average truck size	2,500 gallons water capacity (gwc)
Average number of trips (November through March)	125 per truck
Average savings per additional gallon capacity	$0.05

Product Gallons

Proposed winter filling density (2,500 gal.)(8.345 lb/gal)(48.5%) = 10,118 lbs.
Current winter filling density (2,500 gal.)(8.345 lb/gal)(45%) = 9,388 lbs.

Increased product load 730 lbs.

Increased gallons hauled (730 lbs)÷(4.24 lb/gal) = 172 gallons propane

Annual savings per unit

(172 gal/load)(125 loads/winter)($0.05/gal) = $1,075 per unit

Annual national savings

($1,075 per unit)(18,000 units) = $19,350,000

YUMA 32°45'N. 114°36'W. 141 ft. ARIZONA

Period - Bibliography 30, 33	Temperature: Average daily Max.	Average daily Min.	Average of highest each month	Average of lowest each month	Absolute Max.	Absolute Min.	Relative humidity: Average of observations at 0530	1200	Precipitation: Average monthly fall	Maximum fall in 24 hr.	Average No. of days with 0·1 in. or more
	degrees Fahrenheit						per cent.		inches		
January	67	42	77	31	84	22	57	28	0·4	2·2	2
February	72	46	83	35	92	25	59	27	0·4	2·5	2
March	79	50	91	39	100	31	58	22	0·3	1·5	2
April	86	54	98	44	107	38	56	20	0·1	0·9	1
May	93	60	104	50	120	39	57	18	<0·1	0·9	<0·5
June	102	68	113	58	119	50	56	18	<0·1	0·6	<0·5
July	106	77	113	67	120	61	63	27	0·2	1·4	1
August	104	77	112	67	119	58	68	32	0·6	4·0	2
September	100	70	109	57	114	50	66	29	0·4	3·7	1
October	88	58	100	47	108	38	61	26	0·3	2·5	1
November	76	49	87	37	96	29	57	26	0·2	1·7	1
December	68	43	76	32	83	22	57	34	0·5	2·4	2
Year	87	58	115*	30**	120	22	60	26	3·4	4·0	15
No. of years	67	67	30	30	69	69	44	44	75	75	69

LITTLE ROCK 34°45'N. 92°16'W. 357 ft. ARKANSAS

Period 1880-1949 Bibliography 30, 32, 34	Temperature: Average daily Max.	Average daily Min.	Average of highest each month	Average of lowest each month	Absolute Max.	Absolute Min.	Relative humidity: Average of observations at 0700	1200	Precipitation: Average monthly fall	Maximum fall in 24 hr.	Average No. of days with 0·01 in. or more
	degrees Fahrenheit						per cent.		inches		
January	50	34	70	14	81	-8	79	65	4·8	5·8	10
February	54	36	74	18	87	-12	78	61	3·8	5·2	9
March	63	44	80	27	90	11	76	55	4·5	3·4	10
April	72	53	86	37	94	28	77	54	5·1	9·6	10
May	79	61	89	48	97	39	80	57	4·9	6·3	10
June	87	69	95	59	105	51	81	57	3·8	4·4	10
July	90	72	98	64	108	58	82	53	3·4	6·2	9
August	90	71	97	63	110	52	84	53	3·7	4·1	9
September	84	65	94	51	104	37	84	54	3·1	4·7	7
October	74	54	87	38	93	27	82	55	2·8	6·3	7
November	61	43	77	27	84	10	80	59	4·1	5·9	8
December	52	36	70	19	78	5	80	63	4·1	5·9	9
Year	71	53	90*	10**	110	-12	80	57	48·1	9·6	108
No. of years	67	67	51	51	67	67	43	13	51	70	51

EUREKA 40°48'N. 124°11'W. 60 ft. CALIFORNIA

Period 1883-1949 Bibliography 34, 36	Temperature: Average daily Max.	Average daily Min.	Average of highest each month	Average of lowest each month	Absolute Max.	Absolute Min.	Relative humidity: Average of observations at 0400	1600	Precipitation: Average monthly fall	Maximum fall in 24 hr.	Average No. of days with 0·01 in. or more
	degrees Fahrenheit						per cent.		inches		
January	53	41	64	31	77	20	86	78	7·1	5·1	17
February	53	41	63	32	85	24	87	78	6·5	4·9	15
March	54	43	65	34	78	29	87	76	5·2	3·9	16
April	56	44	66	37	79	31	87	76	3·3	2·9	12
May	57	47	66	41	84	35	89	77	1·8	2·2	9
June	59	50	67	44	85	40	90	77	0·7	2·0	5
July	60	51	66	47	76	43	91	79	0·1	1·2	2
August	60	52	67	48	79	44	92	81	0·2	2·6	2
September	61	51	70	44	85	36	91	80	1·0	2·8	5
October	60	48	73	40	84	34	90	80	2·3	3·6	9
November	57	45	69	36	81	27	88	80	5·2	4·5	12
December	54	42	64	33	70	22	86	79	6·3	4·2	16
Year	57	46	76*	29**	85	20	89	78	39·7	5·1	120
No. of years	60	60	58	58	60	60	57	57	67	63	58

* Average of highest each year

** Average of lowest each year

GREENLAND RANCH (DEATH V.

Period 1911-1952 Bibliography 30, 31, 34, 35	Temperature: Average daily Max.	Average daily Min.	Average of highest each month
			degrees
January	66	38	75
February	72	44	85
March	81	51	93
April	90	60	105
May	99	69	112
June	109	78	119
July	116	87	122
August	114	84	121
September	106	73	118
October	91	59	106
November	76	46	90
December	66	39	77
Year	91	61	123*
No. of years	37	37	10

FRESNO 36°46'N. 119°43'W. 3

Period - Bibliography 30, 34	Temperature: Average daily Max.	Average daily Min.	Average of highest each month
			degrees
January	54	38	68
February	61	42	74
March	66	44	81
April	74	48	88
May	81	53	96
June	91	59	105
July	99	65	108
August	97	63	105
September	89	58	100
October	78	51	91
November	66	43	79
December	55	38	68
Year	76	50	109*
No. of years	43	43	20

LOS ANGELES 34°03'N. 118°15'

Period 1878-1949 Bibliography 30, 32, 34	Temperature: Average daily Max.	Average daily Min.	Average of highest each month
			degrees F.
January	65	46	79
February	66	47	80
March	67	48	83
April	70	50	86
May	72	53	87
June	76	56	90
July	81	60	91
August	82	60	94
September	81	58	96
October	76	54	92
November	73	50	87
December	67	47	81
Year	73	52	100*
No. of years	70	70	53

* Average of highest each year

OES 17°56'N. 76°47'W. 25 ft. JAMAICA

	Temperature: Average daily Max.	Average daily Min.	Average of highest each month	Average of lowest each month	Absolute Max.	Absolute Min.	Relative humidity: Average of observations at 0700	1300	Precipitation: Average monthly fall	Maximum fall in 24 hr.	Average No. of days with 0·04 in. or more
			degrees Fahrenheit				per cent.		inches		
	86	72	89	69	91	67	82	63	0·5	1·9	2
	85	72	88	69	91	67	82	65	0·4	1·1	1
	85	73	88	70	91	68	80	68	0·2	0·4	1
	86	74	89	71	90	69	79	70	1·2	1·7	4
	87	76	89	71	91	69	80	74	2·9	3·8	5
	88	77	91	73	93	72	78	73	4·9	11·3	5
	88	77	92	73	95	71	78	71	2·1	2·1	4
	88	77	91	73	93	70	80	73	5·8	16·9	7
	88	77	92	72	94	70	81	74	6·3	3·7	8
	88	76	91	73	92	70	83	72	6·2	5·2	9
	87	75	91	72	93	69	83	67	2·2	2·7	5
	86	73	90	70	91	67	83	65	1·3	5·5	3
	87	75	93*	64**	95	67	81	70	34·0	16·9	54
	10	10	10	10	10	10	8	8	9	9	9

FRANCE 14°37'N. 61°05'W. 13 ft. MARTINIQUE

	Temperature: Average daily Max.	Average daily Min.	Average of highest each month	Average of lowest each month	Absolute Max.	Absolute Min.	Relative humidity: Average of observations at 0600	1600	Precipitation: Average monthly fall	Maximum fall in 24 hr.	Average No. of days with 0·01 in. or more
			degrees Fahrenheit				per cent.		inches		
	83	69	85	64	90	59	90	77	4·7	2·7	19
	84	69	86	64	91	60	88	73	4·3	1·6	15
	85	69	88	64	91	56	88	72	2·9	2·4	15
	86	71	90	67	94	63	88	71	3·9	2·1	13
	87	73	90	70	93	66	88	74	4·7	4·4	18
	86	74	89	71	92	66	89	77	7·4	3·5	21
	86	74	89	71	90	68	90	78	9·4	4·3	22
	87	74	90	71	94	66	91	78	10·3	7·8	22
	88	74	91	71	96	68	91	79	9·3	6·1	29
	87	73	90	70	94	65	92	80	9·7	4·2	19
	86	72	89	69	92	64	92	81	7·9	4·8	20
	84	71	87	65	89	61	91	79	5·9	3·6	19
	86	72	91*	62**	96	56	90	77	80·2	7·8	223
	22	22	22	22	22	22	23	23	31	23	23

H 16°43'N. 62°13'W. 130 ft. MONTSERRAT

939	Temperature: Average daily Max.	Average daily Min.	Average of highest each month	Average of lowest each month	Absolute Max.	Absolute Min.	Relative humidity: Average of observations at 0900	1500	Precipitation: Average monthly fall	Maximum fall in 24 hr.	Average No. of days with 0·04 in. or more
			degrees Fahrenheit				per cent.		inches		
	82	70	85	66	89	62	69	65	4·8	1·9	12
	83	70	87	66	91	62	66	61	3·4	3·1	9
	85	70	89	65	93	62	65	59	4·4	4·2	9
	86	72	90	68	94	63	62	59	3·5	1·7	8
	88	74	91	70	96	67	63	60	3·8	1·9	10
	88	75	92	71	98	66	65	63	4·4	2·3	13
	87	75	91	72	98	70	66	64	6·1	2·5	14
	88	75	92	71	98	69	68	66	7·2	4·0	16
	89	74	92	70	97	67	68	66	6·6	>12·0	13
	87	74	91	70	94	67	69	66	7·7	7·6	14

SAN JUAN 18°29'N. 60°07'W. 82 ft. PUERTO RICO

Period 1898-1947 Bibliography 69, 71	Temperature: Average daily Max.	Average daily Min.	Average of highest each month	Average of lowest each month	Absolute Max.	Absolute Min.	Relative humidity: Average of observations at 0900	1200	Precipitation: Average monthly fall	Maximum fall in 24 hr.	Average No. of days with 0·01 in. or more
			degrees Fahrenheit				per cent.		inches		
January	80	70	84	66	88	63	81	75	4·3	4·5	20
February	80	70	85	66	91	62	79	74	2·7	4·8	15
March	81	70	86	66	91	63	76	74	2·9	3·6	15
April	82	72	88	68	93	65	75	75	4·1	6·7	14
May	84	74	90	70	94	66	76	75	5·9	5·4	16
June	85	75	90	71	93	66	76	77	5·4	6·5	17
July	85	75	88	72	92	70	77	78	5·7	4·0	19
August	85	76	89	72	93	68	77	77	6·3	6·3	20
September	86	75	90	72	94	69	78	77	6·2	8·5	18
October	85	75	90	71	94	68	79	76	5·6	3·9	18
November	84	73	88	70	93	66	80	76	6·3	8·1	19
December	81	72	85	68	90	62	81	77	5·4	10·6	21
Year	83	73	92*	65**	94	62	78	76	60·8	10·6	212
No. of years	48	48	43	43	48	48	38	19	42	43	43

LA GUÉRITE 17°20'N. 62°45'W. 157 ft. ST.CHRISTOPHER (ST. KITTS)

Period 1929-1952 Bibliography 64	Temperature: Average daily Max.	Average daily Min.	Average of highest each month	Average of lowest each month	Absolute Max.	Absolute Min.	Relative humidity: Average of observations at 0900	1500	Precipitation: Average monthly fall	Maximum fall in 24 hr.	Average No. of days with 0·01 in. or more
			degrees Fahrenheit				per cent.		inches		
January	80	71	83	67	86	64	72	69	4·1	3·5	17
February	81	70	83	67	85	62	69	66	2·0	1·8	11
March	82	71	85	68	89	65	70	65	2·3	7·6	11
April	83	73	85	69	87	67	69	67	2·3	2·3	10
May	84	75	87	71	89	67	72	71	3·8	5·0	12
June	85	76	88	73	89	69	73	71	3·6	5·6	12
July	86	76	87	72	89	70	73	71	4·4	3·2	16
August	86	76	88	72	89	70	74	72	5·2	2·1	16
September	86	76	88	72	91	68	74	73	6·0	6·9	16
October	85	75	88	72	90	69	75	73	5·4	3·7	15
November	84	74	86	71	89	68	76	74	7·3	5·4	17
December	82	73	84	69	87	61	74	72	4·5	2·7	16
Year	84	74	89*	66**	91	61	73	70	50·9	7·6	169
No. of years	19	19	20	19	20	19	19	19	21	21	21

SOUFRIÈRE 14°01'N. 61°00'W. 10 ft. ST. LUCIA

Period 1898-1914 1931-1939 Bibliography 66	Temperature: Average daily Max.	Average daily Min.	Average of highest each month	Average of lowest each month	Absolute Max.	Absolute Min.	Relative humidity: Average of observations at 0700	1200	Precipitation: Average monthly fall	Maximum fall in 24 hr.	Average No. of days with 0·04 in. or more
			degrees Fahrenheit				per cent.		inches		
January	82	69	85	63	87	57	90	70	5·3	3·2	18
February	83	69	85	63	89	59	90	68	3·6	4·2	13
March	84	69	88	64	90	59	88	65	3·8	1·9	13
April	87	71	91	66	95	63	87	64	3·4	3·9	10
May	88	73	92	70	97	67	87	65	5·9	4·4	16
June	88	74	91	70	97	67	86	69	8·6	3·9	21
July	87	74	91	71	95	69	89	71	9·3	2·5	23
August	88	74	91	70	94	68	90	69	10·6	6·9	22
September	88	73	91	70	94	68	91	70	9·9	13·2	21
October	87	72	90	69	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NOV	DEC	ANN
59.7	49.5	70.
25.1	18.0	36.
42.5	33.8	53.
68.7	59.1	79.
39.9	33.1	50.
54.3	46.1	65.
68.0	61.6	76.
42.9	37.2	51.
55.5	49.4	63.
64.9	56.5	75.
35.9	29.7	44.
50.4	43.1	59.
62.3	53.7	71.
27.5	21.6	36.
44.9	37.7	53.
[illegible]8.7	49.2	69.
23.6	17.2	33.
[illegible]1.2	33.2	51.
[illegible]4.9	67.1	85.
42.9	37.4	52.
[illegible]8.9	52.3	69.
[illegible]6.1	48.2	64.
[illegible]1.2	15.7	31.
[illegible]8.7	32.0	48.
[illegible]5.1	67.2	85.
[illegible]2.1	36.3	52.
[illegible].6	51.8	69.
[illegible]5.7	67.5	86.
[illegible].2	35.4	51.
[illegible]3.5	51.5	68.
[illegible].9	61.4	77.
[illegible]7	36.0	49.
[illegible]3	48.7	63.
[illegible].5	56.0	75.1
[illegible].4	28.6	43.7
[illegible]5	42.3	59.
[illegible]7	67.4	84.1
[illegible]8	33.2	49.0
[illegible]8	50.3	66.6
[illegible]9	66.6	83.1
[illegible]0	33.9	49.8
[illegible]0	50.3	66.6
[illegible]2	67.9	84.5
[illegible]8	39.1	54.3
[illegible]0	53.5	69.
[illegible]	65.0	81.7
[illegible]	39.0	54.2
[illegible]	52.0	68.0
[illegible]0	67.3	82.5
[illegible]3	32.6	45.7
[illegible]	49.9	64.1

ARIZONA

TEMPERATURE NORMALS (DEG F)

STATION			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
WALNUT CREEK		MAX	51.1	55.8	60.4	68.2	76.1	86.0	89.7	86.8	83.0	73.4	60.6	52.0	70.3
		MIN	20.2	22.7	24.8	29.2	35.7	43.2	53.3	52.0	43.7	33.5	24.9	19.5	33.6
		MEAN	35.7	39.3	42.6	48.7	56.0	64.6	71.5	69.4	63.4	53.5	42.8	35.8	51.9
WELLTON		MAX	67.6	72.9	77.3	84.3	92.3	101.1	104.9	103.2	99.6	89.9	76.5	68.1	86.5
		MIN	35.2	39.1	44.0	50.0	57.2	66.0	76.5	75.2	67.5	54.9	42.1	35.2	53.6
		MEAN	51.4	56.0	60.7	67.2	74.8	83.5	90.7	89.2	83.6	72.4	59.3	51.7	70.0
WHITERIVER		MAX	52.4	55.7	59.3	67.7	76.8	87.7	90.5	87.0	83.5	74.3	62.0	54.2	70.9
		MIN	22.6	25.2	29.8	35.5	42.6	51.8	59.1	57.1	51.7	41.1	29.9	23.4	39.2
		MEAN	37.5	40.5	44.6	51.6	59.8	69.8	74.8	72.1	67.6	57.7	46.0	38.8	55.1
WICKENBURG		MAX	63.7	68.1	72.2	80.9	90.5	100.8	104.9	101.6	96.9	86.5	73.4	65.5	83.8
		MIN	31.0	34.0	37.8	43.5	51.1	59.8	70.0	68.0	60.0	48.3	37.4	31.3	47.7
		MEAN	47.4	51.0	55.0	62.2	70.8	80.3	87.5	84.8	78.5	67.4	55.4	48.4	65.7
WILLCOX 3 NNW		MAX	58.9	63.3	68.7	77.2	85.9	95.1	95.3	92.1	89.0	79.8	67.4	59.5	77.7
		MIN	25.3	26.5	31.0	36.0	43.2	53.1	63.2	61.2	53.6	41.2	30.3	25.1	40.8
		MEAN	42.1	45.0	49.8	56.6	64.5	74.1	79.3	76.7	71.3	60.5	48.9	42.3	59.3
WILLIAMS		MAX	44.7	47.0	50.7	58.8	67.6	78.1	82.5	79.2	74.9	65.4	53.4	46.7	62.4
		MIN	22.2	23.3	26.3	32.3	39.9	48.9	55.1	53.5	48.2	38.9	28.9	23.6	36.8
		MEAN	33.5	35.1	38.5	45.6	53.7	63.5	68.8	66.4	61.6	52.2	41.2	35.2	49.6
WINDOW ROCK		MAX	41.9	46.0	51.4	60.8	70.7	81.8	85.5	82.4	77.1	67.1	53.1	44.5	63.5
		MIN	12.8	17.2	22.1	28.1	36.1	45.6	54.1	51.8	43.0	32.1	21.5	13.6	31.5
		MEAN	27.4	31.6	36.8	44.5	53.4	63.7	69.8	67.1	60.0	49.6	37.3	29.1	47.5
WINSLOW WSO	//R	MAX	45.0	53.2	60.7	70.0	79.9	91.0	94.5	91.1	85.2	73.1	57.9	46.0	70.6
		MIN	19.0	23.6	29.1	36.0	44.4	53.6	63.0	61.1	52.7	40.1	27.8	19.3	39.1
		MEAN	32.0	38.4	44.9	53.0	62.2	72.3	78.8	76.1	69.0	56.6	42.9	32.7	54.9
WUPATKI NAT MON		MAX	46.9	55.0	62.5	71.7	81.3	92.2	95.9	92.6	86.7	74.4	58.5	47.2	72.1
		MIN	23.7	28.4	33.3	40.2	48.6	58.7	65.1	62.1	56.0	45.1	32.8	24.3	43.2
		MEAN	35.3	41.7	47.9	56.0	64.9	75.5	80.5	77.4	71.4	59.7	45.7	35.8	57.7
YUMA CITRUS STATION		MAX	67.8	73.3	78.2	85.4	93.1	102.1	106.2	104.9	101.1	90.9	77.3	68.9	87.4
		MIN	37.9	40.4	44.3	49.7	56.6	64.5	74.5	74.0	67.3	55.9	44.6	38.7	54.0
		MEAN	52.9	56.9	61.3	67.6	74.9	83.3	90.4	89.5	84.2	73.4	61.0	53.8	70.8
YUMA WSO	R	MAX	68.6	73.9	78.5	85.7	93.6	102.9	106.8	105.3	101.4	90.9	77.4	69.1	87.8
		MIN	43.2	46.1	49.9	55.6	63.0	71.4	80.4	79.5	73.1	61.8	50.2	43.8	59.8
		MEAN	55.9	60.0	64.2	70.7	78.3	87.2	93.6	92.4	87.3	76.4	63.8	56.5	73.9